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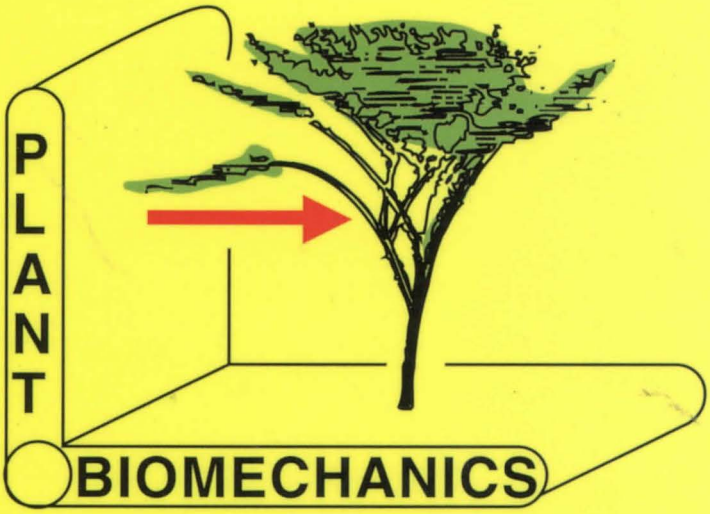

Résumés – *Summaries*

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Measurement of transverse growth stresses in wooden disks

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Wood in standing trees is pre-stressed. These stresses originate in a physico-chemical transformation of wood at the end of its differentiation (cellular maturation). These maturation stresses (often called growth stresses) are useful for trees (they allow bending movements of reorientation or stabilization and reduce the initiation and propagation of shakes in the cambial zone). But they cause troubles during wood processing (heart shakes during felling, deformations and bad quality of sawn wood). The researches leaded in the LMGC of Montpellier aim at modelling these stresses, relating their variations to wood structure and tree growth.

The objective of our work is to validate the mechanical models. To study the stress field along the radius, an destructive experiment based on successive cuts seems necessary. This is a complement to the usual measurements of peripheral strains (Baillères 1994). Among the existing methods (Archer 1986), we have chosen to adapt the Sachs'one (1927).
This method is based on the measurements, at the periphery of a log, of the longitudinal and tangential strains induced by the drilling of successive holes (concentric and centred). These strains as interpreted as the result of the releasing of i) radial stresses of the hole surface and ii) longitudinal stresses on the transverse area supressed. This interpretation have been calculated first by Sachs (for isotropic metals), then by Doi & Kataoka 1967 (on an homogeneous circular cylindrical anisotropic log) and Sasaki & al 1981 (radially unhomogeneous cylindar).

First, we have chosen to implement the experiment on disks (rather than logs). Thus, only the transverse stresses can be valued. The Sachs'calculations have been modified to account for plane stresses, in a very thin, cylindrical orthotropic homogeneous disk. The tangential strain ε_θ at the disk surface is :

$$\gamma^2 = \frac{K_{22}}{K_{11}}$$

$$\varepsilon_\theta = (AR_f^{\gamma-1} + BR_f^{-\gamma-1}).\sigma_{rr}^{o}(R) \text{ with } A = \frac{K_{11}\gamma - K_{12}}{K_{11}\gamma + K_{12}} Rf^{-2\gamma}$$

$$B = \frac{K_{11}\gamma - K_{12}}{(-K_{11}\gamma + K_{12})^2 R^{\gamma-1} Rf^{-2\gamma} - (K_{11}\gamma + K_{12})^2 R^{-\gamma-1}}$$

where $K_{11} = C_{11} - C_{13}^2 / C_{33}$; $K_{22} = C_{22} - C_{23}^2 / C_{33}$ et $K_{12} = K_{21} = C_{12} - C_{13}C_{23} / C_{33}$
(C_{ij} : elastic compliances, R_f : disk radius, R : radius of the drilled hole, $\sigma_{rr}^{o}(R)$: radial stress released by drilling).
The diameter variation $\Delta\phi$ also allows to estimate $\sigma_{rr}^{o}(R)$ since $\Delta\phi/\phi = \varepsilon_\theta$.
The compliances C_{ij} will be calculated from the specific density of wood using Guitard's models for air-dried wood corrected for green wood (Fournier 1989). Simulations have been done, assuming that $\sigma_{rr}^{o}(R) = -\hat{\sigma}_\theta \text{Log}^{R}/_{R_f}$ (Kübler's model).

Experimentally, the disk (≈1cm thick) is prepared with a bandsaw (and a special truck) and put on a hard and smooth bearer (disk of teflon) in order to minimise the risk of adherence. Then, it is necessary to clamp the disk (two opposite tightening points of are sufficient) against cutting forces. Lastly, contrary to what is usually done, the cutting and feeding speeds Vc and Vf are taken very low (Vc≈6,5m/mn ; Vf≈0,01mm/tooth) to avoid vibrations. Moreover, four extensometers (using electric strain gages, H.B.M. type DD1) are nailed (using compasses points) tangentially around the disk , two displacement sensors (Mitutoyo 543) allows to measure the variations of diameter.diamétralement opposés. For each drilled hole, measurements are done after tightening, after drilling, and after loosening.

Figure 1 shows the experimental apparatus and figure 2 an example of results obtained on a disk of poplar I-214. Observed results are slightly lower than theoritical calculations, which can be explained by a partial recovery of locked-in strains during disk conservation.

This experimental device is now operational to evaluate transversal stresses in disks. The aim is to use it to study the variability of these stresses in different species, for different histories of growth, and relate the results to longitudinal strains measured at the stem surface in the standing trees. It will be also used to study the relaxation of stresses with time, temperature, etc. Improvements are planned in the theoretical calculations to take into account asymmetries often observed (eccentricity of the pith, circumferential heterogeneities). Lastly, we will try to develop the same experiment on logs (that will allow also the measurements of longitudinal strains).

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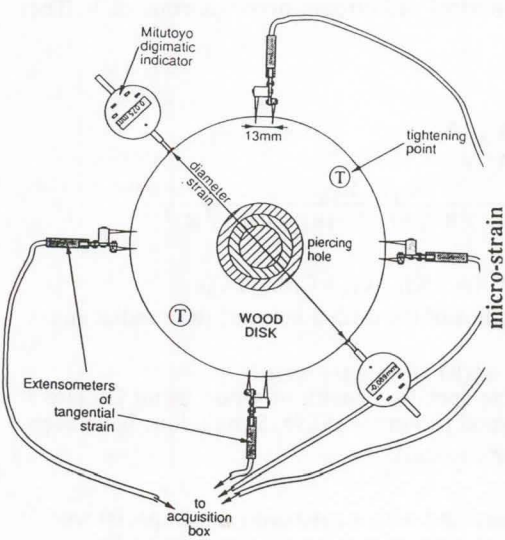

fig 1 : **Pratical Application**

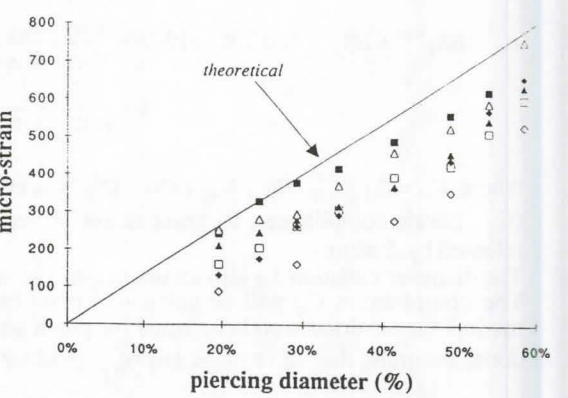

fig 2 : **Experimente Results**